International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s,2025
https://theaspd.com/index.php

"Environmental Sustainability through Traditional Architecture: Innovations in Sustainable Features of Traditional Houses and Their Adaptability in Modern Housing – A Case Study of Sawantwadi, Maharashtra, India"

Chaya Y Chavan[1],Dr. Preetha Jacob[2]
[1] Research Scholar, [2]Professor, School of Planning, Architecture and Design Excellence,
Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India.
[1]rp.20603004@student.hindustanuniv.ac.in,[2]pt.preethj@ hindustanuniv.ac.in

Abstract: *Modern architecture, which frequently disregards the local climate, materials, techniques, and resources, dominates our environment. It began in Western nations in the middle of the 20th century and progressively impacted architectural styles all over the world. Technology has struggled to offer sustainable solutions in the face of climate change. A result of human conduct, environmental degradation and global warming create substantial issues. Rather of adapting valuable traditional designs, modern architecture has gradually replaced them. It is time that we have to think about the Innovations in Sustainable design and adapt in our practices.*

The study aims to explore the innovations in architectural design features of traditional houses in Sawantwadi, Maharashtra, focusing on their environmental responsiveness and potential integration into modern housing practices. This study uses qualitative research methodology which includes plot survey of broad samples, architectural analysis, photographic inventory and discussions with house owners.

The study underscores the how different innovative solutions of sustainable design of traditional practices essentially integrated with the principles of environmental sustainability. By analyzing the adaptability of traditional features in modern housing, the research provides a frame for amalgamating traditional knowledge with current sustainable design approach.

The exploration not only reinforces the value of traditional architecture in approaching modern environmental challenges but also help the development of resilient, context-based housing solutions for the future.

Keywords: *Environment, Architectural Design Features, Adaptability, Traditional Architecture, Sustainability.*

INTRODUCRION

1.1 Overview

In human history, the twenty first century marked as critical period. We are more conscious about the environment. This consciousness has driven the worldwide moment towards the suitability. In consideration with integral role in shaping societies, architecture plays an important involvement in these transformations. It shapes not only the build environment but interact with natural world.

The evolving dynamic shift of architectural design, the amalgamation of timely tested traditional practices with smart technologies emerges a necessary way to environmental sustainability. Traditional architecture is based on natural resources, adjust with climatic conditions, bridging with culture values. On the other hand, the modern green technologies in house, introduce the innovative solutions targeting energy efficiency, resource conservations, use of renewable energy and reducing environmental impact. The merging of this two Domin create a unique opportunity to achieve innovative sustainable architecture which can meet the today's important requirements-environmental sustainability.

The study explores how traditional sustainable values from traditional architectural design features (ADFs) of traditional house are added with modern technology term as innovative sustainable design and adopted into modern house to overcome with limitations of traditional ADFs and meet the environmental sustainability. Through a comprehensive analysis, the study highlights the rewards of this advanced technology which includes reduction in carbon emissions, resource conservations, also enhance the health and well-being of users. It focuses the challenges immersed in adapting Innovative sustainable practices in modern house such as financial considerations, regulatory obstacles and change in cultural identity. It also studies the modern trend that are re-evaluating the built environment.

By analyzing key ADFs through the lens of environmental science, this study pursues to highlight the potential of traditional architecture as a model for modern sustainable housing. The aim is not only to understand these design innovations but also to appraise their adaptability and relevance in today's context of climate change. The study contributes to the progressing dialogue on amalgamation of traditional ecological knowledge into modern architectural practices, paving the way for environmentally conscious and resilient architectural practices.

1.2 Main principles of sustainable architecture

[1] stated that, Sustainability encompasses life, long-term cultural, economic, and environmental health, emphasizing the importance of the relationship between social, financial, and environmental comfort while addressing the needs of all people and taking responsibility for future generations.

Sustainable architecture is known as environmental or green architecture. The three basic principles of sustainable architecture are; conservation of resources, integration of renewable energy and energy efficiency. Energy efficiency can be performed by passive design strategies. Renewable energy can be achieved by adding solar panels, wind turbines This strategy help to reduce the carbon emissions and decreases the electrical bills. Conservation of resources includes reuse of building materials, rain water and grey water harvesting. Water-efficient fixtures, use of passive design for efficiency, integration of renewable energy, green design for well- being, adaptive reuse, smart building technology, NZEBs are the innovative treads in sustainable architecture

2.0 Review of literature

[2] stated that, sustainability in traditional domestic architecture is achieve through climatic considerations, traditional materials and knowledge systems and cultural practices. It supports natural light and ventilations and always attain lower carbon footprints then modern buildings. [3] explains, traditional house is comfortable for natural air flow and lighting. It also establishing the rhythm between nature which help to maintain the quality of life and built environment. [4] described, traditional houses are immensely responsive to the climatic context. Natural thermal insulation is achieved by orientation, spatial organizations, planning of windows/doors, design of attic, and traditional knowledge and resources.[5] reveal that, vernacular architecture developed to complement with specific context, region, socio-culture, economy and exceed into spatial arrangement, forms, patterns and creates identity of particular place.

[6] disclose that, the amalgamation of traditional elements into modern house design improves comfort of users, sustainable practices and maintain the cultural identity. This approach creates the design with innovations, contextual and conserve historical importance. [7] says that, implementation of traditional values into modern house design encourages the harmony between past and present maintaining the relevance in today's context. [8] stated that the addition of traditional house architecture with innovative sustainable design concepts are climate responsive, preserving cultural identity and communicate environmental changes and improves the living conditions.[9] the paper highlights the prospect of sustainable practices discussing innovations in materials and technologies, the development of net-zero energy structure, showcasing the prospect for modern architecture to enhance the modern architecture.[10] affirm that, Innovations in sustainable design for modern houses includes the integrations of solar panels, smart appliances, energy efficient lightings. To conserve water, rainwater harvesting, water-efficient fixtures are also needed. These innovations enhance comforts, functionality, society bonding and well-beings.

[11] paper address, innovative sustainable design approaches include green roofs applied on the sloping roof of residential buildings. Green roof provides ecological benefits and improves the aesthetics. Integrating biophilic design elements help to improve physically and mentally well-being of users. Sloping roof can contribute net- zero energy building. [12] explain the current transformation observed in traditional architecture may be seen, as ways of adaptions and need, as result of modern architecture. The role of architects and planners will be to convinced to protect traditions with innovations and integrate culture, traditions, traditional knowledge system and sources. [13] paper has provided a comprehensive structure for applying principles of sustainable architecture building design and constructions.[14] stated that, effectively integration depends on genuineness, local needs, and education, fostering a dialogue between past and present while enriching cultural heritage. [15] explains, in residential architecture six

levels of adaptability; they are Flexible, Active, Dynamic, Interactive, Intelligent, Smart. [16] the case study discussed in the paper demonstrated that the reductions in the energy consumptions in the innovative green roof are more than 20% compared to the conventional roof. [17] Explain, the adaptability of traditional houses Thai, to modern need to integrate five key credits that, prefabricated structure for easy disassemble and displacement. Modularity for compound integrity, interconnectivity, flexibility and unoccupied areas. These credits not only preserve the traditional architecture but also promote environmental sustainability by reusing resources and less need for new constructions Consideration of traditional houses as archive of sustainability as comfortable place for users would be significant in the determination of modern ADFs [18].

2.1 Research gap

The literature explains the connections between traditional architecture and sustainability but its lacks in innovations in sustainable practice which can be adapted in modern house design and fulfil the current requirements. Hence the research identified the gap as an Indian context- Innovations in sustainable features of traditional houses and their adaptability in modern housing to achieve environmental sustainability is minimal. The study aims to explore the different inventions in sustainable design to integrate in traditional architectural design features (ADFs) of traditional houses of study area and its adaptions in modern house design. To achieve aim, the objective of the study is, to analyzed the limitations of traditional ADFs with respect to current scenario, current trend and demand of modern house.The study helps to solve the research questions,

What are the limitations of traditional prominent architectural design features of houses in the study area when evaluated against the needs of modern living?

How can we overcome with these problems?

Scope of study helps to preserve the prominent traditional ADFs, with maintaining sustainability and cultural identity. Also, the similar study can be replicate in region with other climatic conditions.

2.3 Contribution of the study

The study may be a step towards the innovative sustainable development of the area.

The study might sustain the traditional identity of the houses and town through linking various levels of modern adaptability.

This study may be increases the sensitivity among the people towards the region, their traditional knowledge systems and innovations in sustainable practices.

3.0 Research Methodology

To explore and analysis of traditional architectural design features (ADFs) of traditional houses of study area and its relevance with innovative sustainable architecture the qualitative and quantitative research methodology is used.

3.1 Grounded theory

In social science, qualitative research methodology is commonly used which are grounded in data in systematic way of collections and inductive in nature [20]. It involved theory building approach and includes both quantitative and qualitative approach. The goal of this theory is to create the new theory than using existing one. To collect the systematic data for study the extensive group of two hundred and sixty-nine samples were considered. The inductive coding was assigned for the data. The simultaneously and continuously analysis of data were drawn to link between the traditional to modern innovative sustainable design. The information's were collected through primary and secondary data.

3.2 Approach used for the research

Table 1. Summary of the approach used for the research

Source: Author

Sr.no.	Method	Data collection methods	Analysis methods	Result
	Literature review	Books, research papers, reports, descriptive and prescriptive writings which	A content analysis method was used to draw out the information.	Different categories and patterns were discovered in connections with

		discusses of innovative sustainable design.		innovative sustainable practices. Adaptability levels were finalised.
	Plot survey of houses	Mapping, observations, photographic survey and discussions with house users.	Architectural analysis The meanings and understanding are developed through people interactions and observations and meaningful patterns were drawn.	This data help to identify the prominent ADFs of traditional houses of study area and its linkage with Innovative sustainable design.
	Users' responses:	Discussions with users'	Excel worksheet	Final list of prominent ADFs were ready.

3.3 Research methodology flowchart

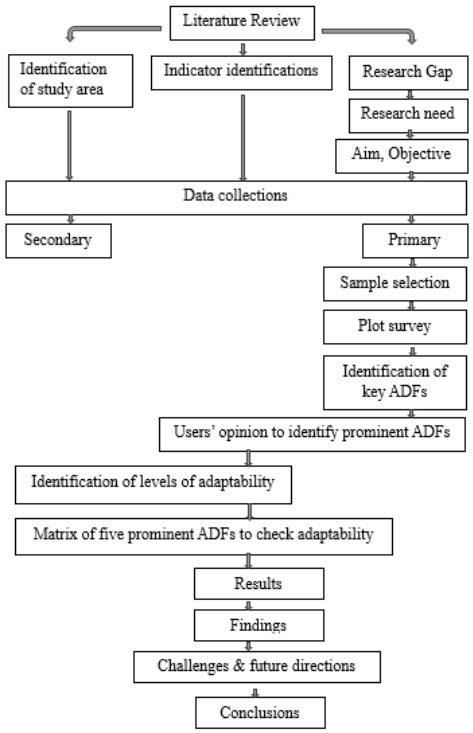


Fig.1. Research methodology flowchart
Source: Author

3.4 Sawantwadi, Maharashtra, India: A study area

The Sawantwadi is heritage town under coastal Maharashtra (near Goa, India), and part of Western ghats region. It is part of UNESCO's world heritage sites of natural landscape category. It has longitude and latitude are 15.9053° N, 73.8213° E respectively, and tropical climate with temperature varied between 27 °C and 34 °C. It is famous for production of wooden children's toys and *Ganjifa*. *Ganjifa* is a playing card traditional painted with manually.

Fig. 2. India map shows Maharashtra and Sawantwadi Maharashtra state, India.
Source: India Map States

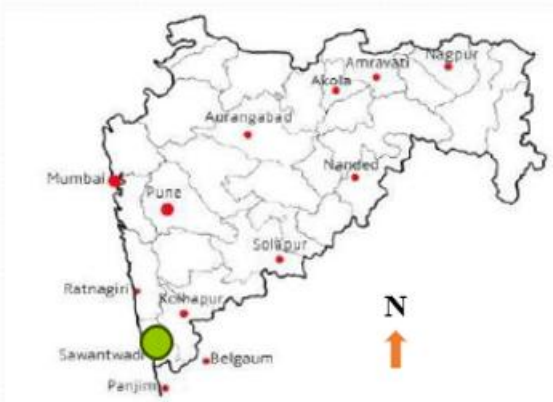
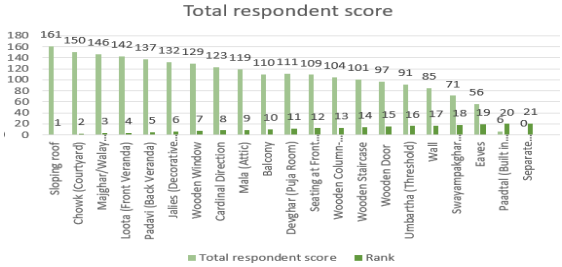


Fig. 3. The location of Sawantwadi
Source [30]



The history of town is very rich and the town was well connected to various places through ports much before the arrival of Portuguese. Due to the continuously various development, the area is becoming at risk towards apathy of change in environment followed by transformation in character of the houses and town [30].

The changes in traditional ADFs are affecting the environmental conditions inside the house and as well as surroundings, and it will impact the environment.

3.4.1 Selection of Samples

The data of extant houses of selected span, collected from the competent authority and in connection with broad survey, observation methods and photographic inventory, the two hundred and sixty-nine samples (traditional houses) were identified for study. The comprehensive plot survey of identified samples was done to identify the prominent traditional architectural design features (ADFs) and its sustainable design values which can be adapted into the modern house design in innovative ways.

3.4.2 User's opinion: The users who lived more ten years in sample were considered for the opinion about the adaptability of prominent traditional ADFs from traditional to modern house design to preserve the unique identity of houses and the town. The calculations of number of users from samples are done by Taro Yamane formula. The one hundred and sixty-one users from two hundred and sixty-nine samples were considered for opinion.

The preferences of traditional ADFs were evaluate based on one hundred and sixty-one users' opinion with a qualifying score set at 70%. As per the user's opinion nine prominent ADFs were qualified out of twenty-one key ADFs. To study the innovations in sustainable design of traditional architectural design features of traditional house and its adaptability in Modern House, five ADFs (rank wise) were considered for demonstrations.

Fig. 4. Respondent score
Source: Author

3.4.3 Chi-Square Test and Cramér's V: The Chi-Square Test of Independence is used to check the associations of twenty-one key ADFs, to evaluate whether the variables are significantly associated. Additionally, Cramér's V was calculated to quantify the strength of each association. Five ADFs (rank wise) were presented here for demonstrations.

i. Sloping roof: In case of Sloping roof, no statistics are computed because these requirements are constant to all samples.

ii. *Chowk* (Courtyard): The Chi-Square indicate a significant association between the typology & variables. Cramer's V (1.000) indicating a very strong association.

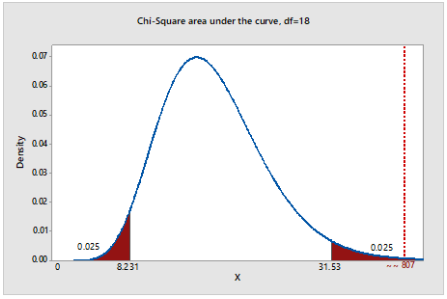


Fig. 5. Chi square test – courtyard
Source: Author

iii. *Majghar* (Living): The Chi-Square value of Living room is 807, shows significant association between the typology & variables. And the Cramer's V is 1.000 presents strong associations.

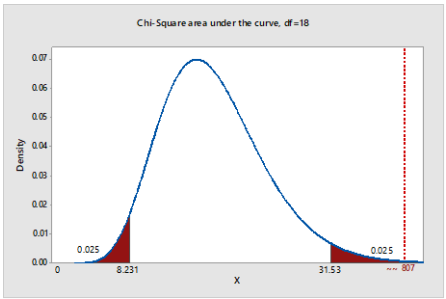


Fig. 6. Chi square test – Living room
Source: Author

iv *Loota* (Front Veranda): Chi- square test highly significant association between the typology & variables i.e. $p<0.001$, and Cramer's V (1.000) suggest a very strong association.

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 16s,2025
https://theaspd.com/index.php

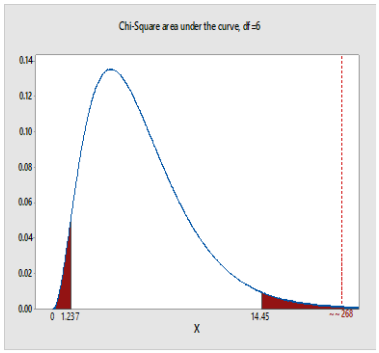


Fig. 7. Chi square test – *Loota* (Front veranda)

Source: Author

v *Padavi* (Back Veranda): Chi square value of front veranda is 269, and Cramer's V (1.000) suggest a very strong association.

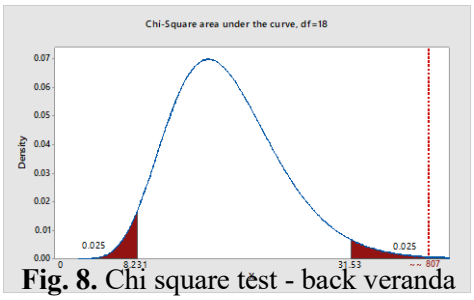


Fig. 8. Chi square test - back veranda

Source: Author

4.0 Analysis of five prominent architectural design features

4.1. Sloping roof

4.1.1 Traditional sustainable values: The study area receives heavy rainfall. Hence sloping roof is the important climate responsive design feature, help to improve ventilation and cooling while contributing in the prevention of water leakage. It is inclined at an angle of 35^0 which help to reduces the solar beam radiations [3]. The extended roof beyond the wall, protect the wall from harsh sun and heavy rain. The roof covering tiles are placed in two layers which reduces the heat gain. The attic is added at roof which act as outlet for hot air and helps to reduces the temperature of the house. It will play the important role to maintain the traditional skyline of the town.

4.1.2 Key challenges in the current context: At the time of interactions with users, the main issue reported with sloping roofs is the need for yearly maintenance.

4.1.3 Solutions aligned with contemporary needs: Integration of sensors and monitoring systems to assess the roof's condition.

4.1.4 Suggestions: The traditional sloping roof which required yearly maintenance and it is expensive too. Installation of smart moisture attic sensors decreases the maintenance problem and increases lifespans of the house. Integrating improved lighting PV system with advanced storage technologies for energy self-sufficiency. Advanced skylights help for energy savings.

4.2 *Chowk* (Courtyard)

4.2.1Traditional sustainable values: The courtyard is distinctive features and had great contribution to the sustainable practices. It is also term as the microclimate modifier. It provides cross ventilations, natural light and adjust humidity. It is also used for the rain water harvesting.

4.2.2 Key challenges in the current context: In nuclear families, an open-to-sky courtyard is challenging due to safety concerns.

4.2.3 Solutions aligned with contemporary needs: Provision of retractable roofing systems above the courtyard.

4.2.4 Suggestions: In current scenario, increase in number of nuclear families, an open-to-sky courtyard is challenging due to safety concerns. Hence integration of smart roof above courtyard is the option which allows the increase or decrease in amount of light and ventilation and to help, shield the interior space from different climatic conditions and provide safety. The space can use for multi activity providing smart screen can enhance privacy during work without compromising the integrity of the main space or occupying excessive area. It is also used for rain water harvesting. Integration of smart devices help to conserve energy and support the sustainable practices.

4.3 *Majghar /Walay* (Living)

4.3.1Traditional sustainable values: *Majghar/Walay* is the centrally located space with more height than surrounding rooms. Hence the interior of this area is very cool and comfortable. It does not require any artificial cooling, even during the summer.

4.3.2 Key challenges in the current context: In consideration with current demand the size of the living room is small.

4.3.3 Solutions aligned with contemporary needs: A smart partition can be used, instead of a fixed wall between the front and back veranda and the living area, to create flexible space when needed.

4.3.4 Suggestions: Traditionally the living room sizes are small due to the various limitations such as availability of wooden sizes. Use of advanced sustainable materials helps to overcome with these problems. The smart divisions enhance the efficiency of the space. Integration of smart lighting, furniture, climate control helps to fulfil the users need considering present scenario.

4.4 *Loota* (Front Veranda) and 4.5 *Padavi* (Back Veranda)

4.4.1 & 4.5.1Traditional sustainable values: A veranda adds passive sustainable design features helps to enhance the indoor comfort and energy efficiency. It allows natural ventilations and diffuse sunlight and reduces the temperature of the incoming air. Additionally, it allows windows to remain open even during rain, providing a sheltered yet well-ventilated space. *Loota* with *jalis* facilitates light and ventilation control, filters dust, acts as a visual barrier and creates intricate shadow patterns. A *loota* with a series of pillars offers structural support, also contributing to aesthetic appeal through rhythmic patterns.

4.4.2 & 4.5.2 Key challenges in the current context: Fixed jalis provided at veranda might be uncomfortable during cloudy climate or winter.

4.4.3 &4.5.3 Solutions aligned with contemporary needs: Innovative sliding and sliding and folding screens can be incorporated into modern house to achieve innovative smart sustainable and aesthetically pleasing design.

4.4.4 & 4.5.4 Suggestions: Fixed jalis /screen are provided at veranda might create problems in cloudy and winter days which may not allow light enter into internal part of the house. If this sustainable feature can modify as per requirement with open and close screen (rotatable) as per sun path. Also moves and slides as per requirements.

5.0 Results

The study revealed two hundred and sixty-nine traditional houses in study area are still are in good conditions. The twenty-one keys traditional ADFs and nine prominent traditional ADFs were uncover to have high potential to adapt the innovations. Field survey, photographic inventory, discussions with users highlighted the continued relevance and resilience of all these ADFs in the face of changing climate conditions. Prominent ADFs enhance the environment sustainability of contemporary designs with accommodating functionality and aesthetics.

The important results of five prominent ADFs are:

Sloping roof: Effective for climate control. It strengthens structural longevity and energy efficiency by adoptions of solar panels, advanced skylights and smart moistures detector.

Courtyard *(Chowk)*: Traditionally it is the source of natural light and ventilations. It can be advanced by adding smart roof covering and environmental control to overcome with safety problems and more functional in urban and nuclear family settings.

Living room *(Majghar/Walay)*: It is coolest place, can be enhances by using modular smart elements to achieve the flexibly and better utility of the space.

Front and Back Veranda *(Loota and Padavi)*: These are the transitional spaces helps for airflow and shading. This can enhance with smart moveable screen and advance materials helps to achieve the results as per climate change.

These results assert that, when traditional architectural design features (ADFs) furnish with intelligent technology, can effectively render to achieve the environmental sustainability.

6.0 Findings

The study's main findings uncover that traditional architectural design features from Sawantwadi traditional houses hold considerable sustainable value, can be boost through modern inventions.

Traditional architectural design features, courtyard and sloping roof help with passive solutions and decreases the dependency on mechanised systems.

In urban and nuclear family settings, modern innovations help to address the limitations of traditional architectural design features includes safety, maintenances, space managements.

The user's interaction established the high level of acceptance in integration of traditional ADFs into modern house enhanced with smart functionality.

Detailed adaptability matrix of five architectural design features helping to envision their transformation to smart design solutions.

These knowledge supports to create new design philosophy in combination with local wisdom and modern inventions to entitle new architectural solutions that maintain the cultural identity and achieve the environmental sustainability through innovations.

7.0 Challenges and future directions

The innovative sustainable design requires higher initial costs compared to the conventional design. The initial cost discrepancy can discourage owner to adapt innovative sustainable design. Lack of awareness among the clients and developers regarding the long-term benefits of innovative sustainable design. This shows the unwillingness to invest in innovative sustainable design. Supports from competent authority sometimes became the obstacles.

Inspiration from nature's pattern and forms achieve the functionality and aesthetical pleasing design. Use of smart technology such as use of AI and BIM enhance the building performance at the design stage. Addition of regenerative design concept which generate more energy than the consume, restore and help to encourage biodiversity.

8.0 Conclusion

The study focuses, the integration of advanced technologies into traditional architectural design features encouraging modern sustainable architectural design which hold solemn agreement for the future of domestic architecture. The innovative environmentally sustainable design and advanced technology build up energy efficiency and increase the lifespan of the house. It also discusses the how innovative solutions can balance the traditional identity of house and town, while balancing the aesthetic appearance, benefits and environmental balance. Incorporation of renewable energy such as solar is the need of energy self-sufficiency. Effective window design maximises natural light and ventilation and reduces the use of mechanical light and ventilations. Solar panels maximize resource efficiency and help to reduce environmental impact. Use of smart device reduces energy use and balances efficiency level of occupants. Reduction in water consumption with the help of rain water reuse. Integration of smart technologies to control the house systems and monitor the spatial use. It helps to enhance the efficiency and energy savings.By examining traditional ADFs through field surveys, architectural analysis, and community engagement, the research confirms their relevance in addressing contemporary environmental challenges. Such study is the way towards the new house design. The research underscores that integration of smart technologies such as sensor system, automotive shading system, renewable energy proceeds towards the modern architectural design features while preserving their aesthetic integrity and functions. This amalgamation supports passive design and achieves long term environmental goal.Moreover, the findings motivate future professionals and planners rethink traditional practices and reconsider them through the lens of modern sustainable practices. It highlights the essentials for architectural practice and education to adapt contextual, innovative design strategies to focus both sustainable mandates and cultural identity. Embracing innovations in sustainable traditional ADFs in modern architectural practices can bridge the gap between heritage and innovation, paving the way for a more sustainable built environment.

REFERENCES

[1] M. Davoodi and S. Akhlaghdoost, "Principles of Sustainable Architectural Design in Environmental Conservation".
[2] M. Xu, "Bridging traditions: The synergy of historical wisdom and modern sustainable practices in architecture," *Appl. Comput. Eng.*, vol. 66, no. 1, pp. 160–165, May 2024, doi: 10.54254/2755-2721/66/20240942.
[3] I. P. G. Suyoga, M. A. A. Widyatmika, and N. K. A. Juliasih, "Bali Traditional Architecture: Sustainability from the Perspective of Capital Concept," *Int. J. Interrelig. Intercult. Stud.*, vol. 3, no. 2, pp. 50–57, Dec. 2020, doi: 10.32795/ijiis.vol3.iss2.2020.1090.
[4] R. Dayaratne, "ISVS e-journal, Vol. 1, no.1," vol. 9, 2022.
[5] A. Kaushik and D. P. Narkhede, "Environmental Conformity in Vernacular Settlement Planning:," 2018.
[6] Z. Zhang, "The Influence of Traditional Architectural Elements on Modern Building Design," *Highlights Sci. Eng. Technol.*, vol. 113, pp. 131–142, Oct. 2024, doi: 10.54097/09wxhb32.
[7] E. Hosseini, G. Mursib, and R. N. Raja Shahminan, "Implementation of Traditional Malay Design Values in Contemporary Malay Houses," *Int. J. Built Environ. Sustain.*, vol. 3, no. 2, May 2016, doi: 10.11113/ijbes.v3.n2.125.
[8] V. K. Tran, "The integration of traditional and advanced design in the formation of sustainable New Rural Housing solutions.," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 143, p. 012053, Apr. 2018, doi: 10.1088/1755-1315/143/1/012053.
[9] P. Patel and A. A. Sharan, "Embracing Sustainable Living: Modern Trend in Architecture".
[10]A. S. Duseja, "Homes for Tomorrow: The People-first Path to Sustainable Design".
[11]N. Nasrullah and S. Syafri, "Innovative Sustainable Design Approaches in Urban Architecture: Balancing Aesthetics and Environmental Impact," *Glob. Int. J. Innov. Res.*, vol. 2, no. 9, pp. 2007–2024, Sep. 2024, doi: 10.59613/global.v2i9.290.
[12]A. Srivastava, B. K. Das, and M. Arch, "Vernacular Architecture in India: A Review Article".
[13]Azubuike Chukwudi Okwandu, Dorcas Oluwajuwonlo Akande, and Zamathula Queen Sikhakhane Nwokediegwu, "Sustainable architecture: Envisioning self-sustaining buildings for the future," *Int. J. Manag. Entrep. Res.*, vol. 6, no. 5, pp. 1512–1532, May 2024, doi: 10.51594/ijmer.v6i5.1098.
[14]Z. Zhang, "The Influence of Traditional Architectural Elements on Modern Building Design," *Highlights Sci. Eng. Technol.*, vol. 113, pp. 131–142, Oct. 2024, doi: 10.54097/09wxhb32.
[15]K. Y. Kai, "Adaptability and Flexibility in Architecture Concepts & Theories Applied in Residential Architecture to Achieve Adaptability".
[16]C. Lelieveld and L. Voorbij, "Dynamic Material Application for Architectural Purposes," presented at the CIMTEC 2008, Sep. 2008, pp. 595–600. doi: 10.4028/www.scientific.net/AST.56.595.
[17] S. Ramasoot, "Sustainability via Adaptability: Learning from the Traditional Thai House's Built-for-Change Architecture," *Journal of architectural plannig research and studies,* vol. 10, no. 1, 2013.
[18] Dincyurek, O.,Learning from traditional built environment f Cyprus: Re- interpretation of the contextual values. *Building and Environment, , 42*(9), 3384-3392. (2007). doi: 10.1016/j.buildenv.2006.08.007.
[19] Das2, A. S., Vernacular Architecture in India: A Review Article. *ISVS e- journal*, 435-448. (2023).
[20] Barney G. Glaser, A. L.,*The Discovery of Grounded Theory.* New York: Aidine de Gruyter., (1967).
[21] Hyde, R. (2000) Climate Responsive Design—A Study of Buildings in Moderate and Hot Humid Climates. E and FN Spon, London, 57.
[22] Ahmed Bilal Awan. (2019). "Optimization and techno-economic assessment of rooftop photovoltaic system",. J.Renewable Sustainable Energy.
[23] Mudit Saxena Joshua Rasin, L. L. (2010). Advanced Skylights: Determining the Low Angle Sun Advantage. American Solar Energy Society (ASES) - Solar Conference. American Solar Energy Society .
[24] Mills, K. (2024, January). Roofcrafters. Retrieved from https://www.roof-crafters.com/: https://www.roof-crafters.com/
[25] Richa Gupta & MahendraJoshi. (2021). Courtyard: A Look at the Relevance of Courtyard Space. Civil Engineering and Architecture, 2261-2272.
[26] Cederquist, E. (2018). Designing Private Spaces with Room Dividers and Partitions. Journal Hospital Design.
[27] Alothman, H. (2017). An evaluatve and critical study of mashrabiya in contemporary architecture.
[28] Ritu Gulati & Yatin Pandya. (2014). "Comparative Thermal Performance of Vernacular Houses at Lucknow :A Quantitative Assessment and Dominant Multiple Strategies,". CEPT University, (pp. 1-8). Ahmedabad.
[29] Tamil Salvi Mari, S. G. (2021). THE VERANDA: ABSTRACT CONNECTOR OF LIVING BOXES - ARCHITECTURAL ANSWER TO SOCIAL HARMONY. Journal of Engineering Science and Technology(special issue 5), 164 – 175.
[30] Shah, M.*Urbanisation and its effect on vernacular houseform:A study of Sawantwadi, Maharashtra.* Ahemdabad: CEPT University. (2017).